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SURFACE HARDENING EQUIPMENT

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Use of a new device UDGZ-200 is considered for surface hardening. Its use increases the service life of body components, gear connections, crane wheels and rails, dies, etc., due to a marked reduction in machine and equipment down time. Its introduction does not require workshop modernization: it is capable of compensating for a lack of traditional heat treatment equipment.

Surface hardening of steel components has marked advantages over bulk hardening. A ductile core provides hardened components with increased breakage resistance on impact, rapid cooling (due to the small heating volume and two-sided heat removal, i.e., into the external cooling medium and into the cold inner part of a steel component) makes it possible to strengthen large steel objects with low hardenability. Introduction of surface hardening into production has made it possible to broaden the range of hardened components and as a result of this to increase machine reliability and reduce the frequency of breakdowns.

Surface hardening also has some disadvantages: of methods known for its performance, i.e., gas flame, high-frequency current (HFC), electron and laser beam, in an electrolyte, etc., only the first two methods are widespread, and they are not always used. Mainly for this reason in contemporary machines there are still many unhardened components that wear rapidly and become a reason for repair. In order to resolve the important problem of increasing accessibility to surface hardening, a *UDGZ-200 hardening device has been developed*, intended for surface hardening components by a plasma arc. The device consists of a supply source, a hardening torch, and a water cooling unit (Fig. 1).

A welder hardens an outer surface area by strips 7–14 mm wide with a coverage of 20–50% using the hardening torch. The thickness of the hardened layer is up to 2 mm, and as with normal hardening the hardness depends on steels grade: HRC35 for steel 20GL, HRC65 for steel 65G, etc. Over hardened strip seam lines, the hardness is lower by 20–50% as a result of tempering processes.

The cooling rate required for hardening is provided as a result of heat conduction into the cold body of a component with supplying water [1]. This simplifies organization of work (it excludes water supply and collection) and makes it possible to carry out hardening not only in specially heated areas, but also in universal repair sites.

Plasma hardening does not cause deformation, and does not worsen surface roughness in the range Rz 4-40. Temper color at a hardened surface may be removed as required by a wheel, but often a hardened component is sent for operation without finishing grinding.

The main amount of welding within the world (more than 80%) is carried out with electrodes or semiautomatic units, i.e., manually. Development of the UDGZ0200 device makes it possible to simplify the complex process of hardening. It provides access to difficult areas. It is possible to equip the UDGZ-200 device with specialized automats or robots. The Ural Wagon Plant corporation has started automating the UDGZ-200 device.

Strengthening of geared joints is possible by both established methods (carburizing, HFC and gas flame hardening, nitriding), and also by plasma hardening.

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Fig. 1. UDGZ-200 unit for surface hardening.

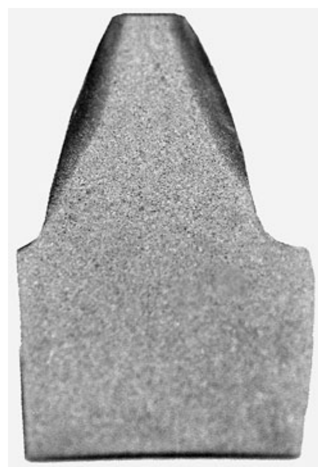

Fig. 2. Macrosection of a tooth with plasma hardening (×2).

A typical hardened layer configuration and structure (after plasma hardening) on a steel 38KhS tooth is presented in Figs. 2 and 3. The basic metal has a ferritic and pearlitic structure. The hardened layer, revealed by etching, extends to a depth up to ~2 mm. In the direct vicinity of the surface (up to 0.6 mm), there are areas with high microhardness values of HV668-783, alternating with areas of lower microhardness of HV344. Probably this is explained by a nonuniform carbon content of ferritic and pearlitic grains that cannot be overcome with rapid heating by a plasma arc. With an increase in distance from the surface, microhardness gradually decreases to the level of the basic metal.

Plasma hardening of teeth is only performed for the side surfaces of a tooth. The spaces between teeth are not hardened since there is no access for a hardening torch. With HFC hardening, this is a considerable disadvantage giving rise to tooth breakage during operation. Plasma hardening of only the side surfaces does not lead to breakages. This is probably connected with the fact that plasma hardening is carried out successively for individual fragments, but HFC hardening is performed simultaneously for a whole profile with creation of high residual stresses. At the Kachkanar Ore Enrichment Plant, the driving gears of railroad locomotives with HFC hardening to a high hardness broke rapidly, and with hardening to a lower hardness they wore rapidly. Use of plasma hardening made it possible to overcome tooth breakage without a reduction in wear resistance.

In 2005, at the Kachkanar Ore Enrichment Plant test plasma hardening was carried out for *gear wheels and two working head mechanisms of a EKG-10 quarry excavator* (Fig. 4). Operation showed that wear of the hardened areas slowed down considerably (by a factor of ~3).

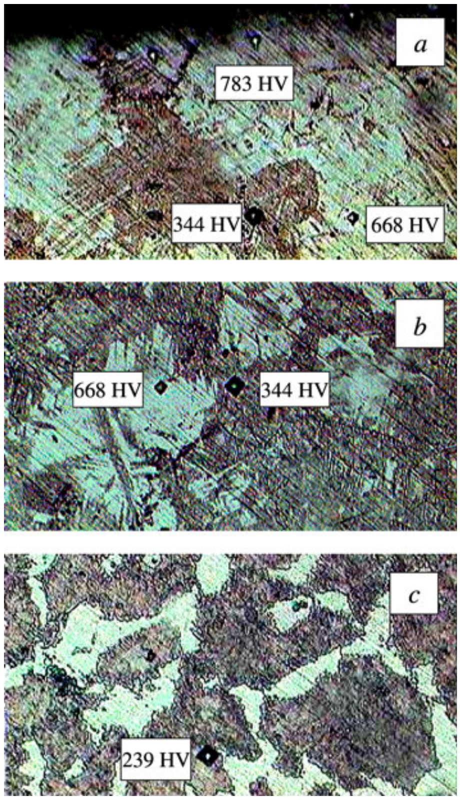

Fig. 3. Macrostructure of a tooth with plasma hardening (×300): *a*) at surface; *b*) beneath surface (to 0.6 mm); *c*) basic metal.

Fig. 4. Teeth and cable channel with plasma hardening in "head" mechanism of an EKG-10 quarry excavator.

Fig. 5. Die with plasma hardening.

Testing in a friction machine showed as a result of plasma hardening that there is a reduction in wear of *rail steel* by a factor of ~120 [2]. This served as a basis for carrying out hardening of workshop rails for transfer cars at the Chelyabinsk Pipe Rolling Plant (ChTPZ). Inspections carried out in 2007–2011 showed that wear and rail consumption was reduced by more than a factor of ten. The same rate of wear reduction was also revealed in hardened guide rails R18 in a flow line for producing wheel axes at the Uralwagonzavod. Similar results have been demonstrated for crane wheels and brake blocks hardened by the UDGZ-200 device.

In 2004, research was started for plasma hardening of cast iron *dies* for molding pipes of considerable diameter [3]. In the cast conditions, their hardness was HRC 30, and this was increased by gas plasma hardening to HRC 50. Use of plasma hardening increased hardness to HRC 60, and die life by a factor of ~3 [4].

In the 1990s, in order to increase the life of multitonnage dies made of steel 5KhNM tempering after hardening was started at a lower temperature. This caused die splitting. Then the tempering temperature was restored to the previous value, but in order to increase die operating life the surface was hardened in a UDGZ-200 device (Fig. 5).

Many dies (composite) have a prolonged manufacturing cycle with cutting into small parts for bulk hardening, and subsequent difficulties of alignment of fragments into a single unit. An experiment was carried out for replacing bulk hardening of parts of a composite die by plasma hardening, and this made it possible to avoid alignment of hardened parts (~30% of the overall difficulty of die manufacture), i.e., they were made directly according to the drawing dimensions. More than 70 thousand components were made in this die, and it retained its operating condition. The labor content of repair “cleanings” due to reducing their frequency and duration, was lessened by a factor of ~10.

Conclusion. The UDGZ-200 device developed in 2002 makes it possible to expand considerably the sphere of surface hardening application.

Use of the device makes it possible to increase considerably the service life of body parts, geared joints, crane wheels and rails, dies, and as a result of this to reduce markedly (by a factor of two or more) downtime for machines and equipment.

Introduction of the UDGZ-200 device does not require capital expenditure for modernizing production workshops. In a number of cases, plasma hardening has been carried out at repair sites, and even in the open air.

REFERENCES

1. V. A. Korotkov, S. P. Ananiev, and A. V. Shekurov, “Study of the effect of cooling rate on surface layer quality with plasma hardening,” *Svar. Proizvod.*, No. 3, 23–27 (2012).
2. S. P. Ananiev, V. A. Korotkov, and V. V. Kozlov, “Study of crane rail and wheel material wear resistance,” *Vestn. Mashinostr.*, No. 8, 35–37 (2011).
3. M. V. Zlokazov, “Use of plasma hardening for die tool strengthening,” *Remont. Vosstanovl., Moderniz.*, No. 2, 10–14 (2006).
4. V. A. Korotkov, A.V. Shekurov, D. S. Babailov, et al., “Cast iron die plasma hardening,” *Remont. Vosstanovl., Moderniz.*, No. 1, 31–34 (2007).